Space Weather Technical Forecast

Issued on Friday, 06 January 2023 at 12:57 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of X-class flares throughout. Slight chance of G1/Minor Geomagnetic Storm interval today (6th Jan).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been High with an impulsive X1.2 flare at 06/0057 UTC, originating from AR3182 (Eki/Beta-Gamma) in the southeast quadrant, which is the largest on the visible disc. The X1.2 flare also produced an R2-R3 radio blackouts. This region has a complex magnetic structure, which may develop a delta spot, although the region needs to be rotated further around from the southeast quadrant for a better analysis. There are six other regions on the visible disc, of which, AR3177 and AR3181 are the most likely to produce significant flares. This is despite the simple classification of AR3177, which has a history of producing large C-class flares. AR3183 (Dai/beta-gamma) rapidly developed through the period, with AR3180 (Dso/beta-gamma) relatively small and apparently stable. A new and currently unnumbered region has recently emerged in the southwest quadrant, which is classified as a Cao/Alpha. No Earth-directed CMEs have been observed in the past 24 hours.

Solar Wind / Geomagnetic Activity: Solar winds, observed at L1 started the period at slow-ambient levels, before increasing to slightly elevated and elevated levels, peaking at 546km/s at 06/0903 UTC. Density was average to above average, peaking at 22 ppcc at 06/0422 UTC. Total magnetic field strength (IMF) was initially at moderate levels, peaking at 15nT at 05/1258 UTC, declining briefly to weak levels, before increasing to the current moderate levels. The north-south component Bz had a prolonged negative period from midday to early evening, mostly at weak levels but occasionally becoming moderately negative, reaching -10nT at 05/1936UTC. Phi angle was negative (towards the Sun) throughout. Geomagnetic activity remained at Quiet to Unsettled levels (Kp 0-3). The solar wind environment indicated residual CME effects (from the 4th) along with a likely connection to a HSS from either CH60 or CH61.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) as measured at GOES16 remained at background levels. High energy electron flux (greater than 2MeV) has been at background to moderate levels, peaking at 214 pfu at 05/1850 UTC. The 24-hour integrated electron fluence remained below the Active threshold with a falling trend, reaching 2.67e6 integrated pfu by 06/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is likely to be Low to Moderate, with a chance of X-class flares through the forecast period, these most likely from AR3182.

Solar Wind / Geomagnetic Activity: The effects of a CME which arrived at Earth on 04 January are expected to continue to subside over the next 12 hours. A CME may glance Earth on late on day 1 (6th Jan), but with low confidence. A weak high speed stream, from either coronal hole 60 or 61 is likely to persist day 1 (6th Jan) possibly early day 2 (7th Jan), before declining. Geomagnetic activity is expected to be Quiet to Unsettled (Kp 2-3) day 1 (6th Jan),

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with isolated Active (Kp 4) periods likely, and a slight chance of a G1/minor geomagnetic storm (Kp 5). From day 2 (7th Jan) predominantly Quiet (Kp 0-2) conditions are expected.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux observed by GOES-16 is expected to remain at background levels throughout with a chance of rising alongside any notable flares, giving a slight chance of exceeding the S1/Minor Storm threshold. High energy electron flux (greater than 2MeV) levels are expected to be at background to moderate levels. Therefore the corresponding electron fluence values are forecast to remain below the Active (1e8 integrated pfu) levels, despite an increasing trend.

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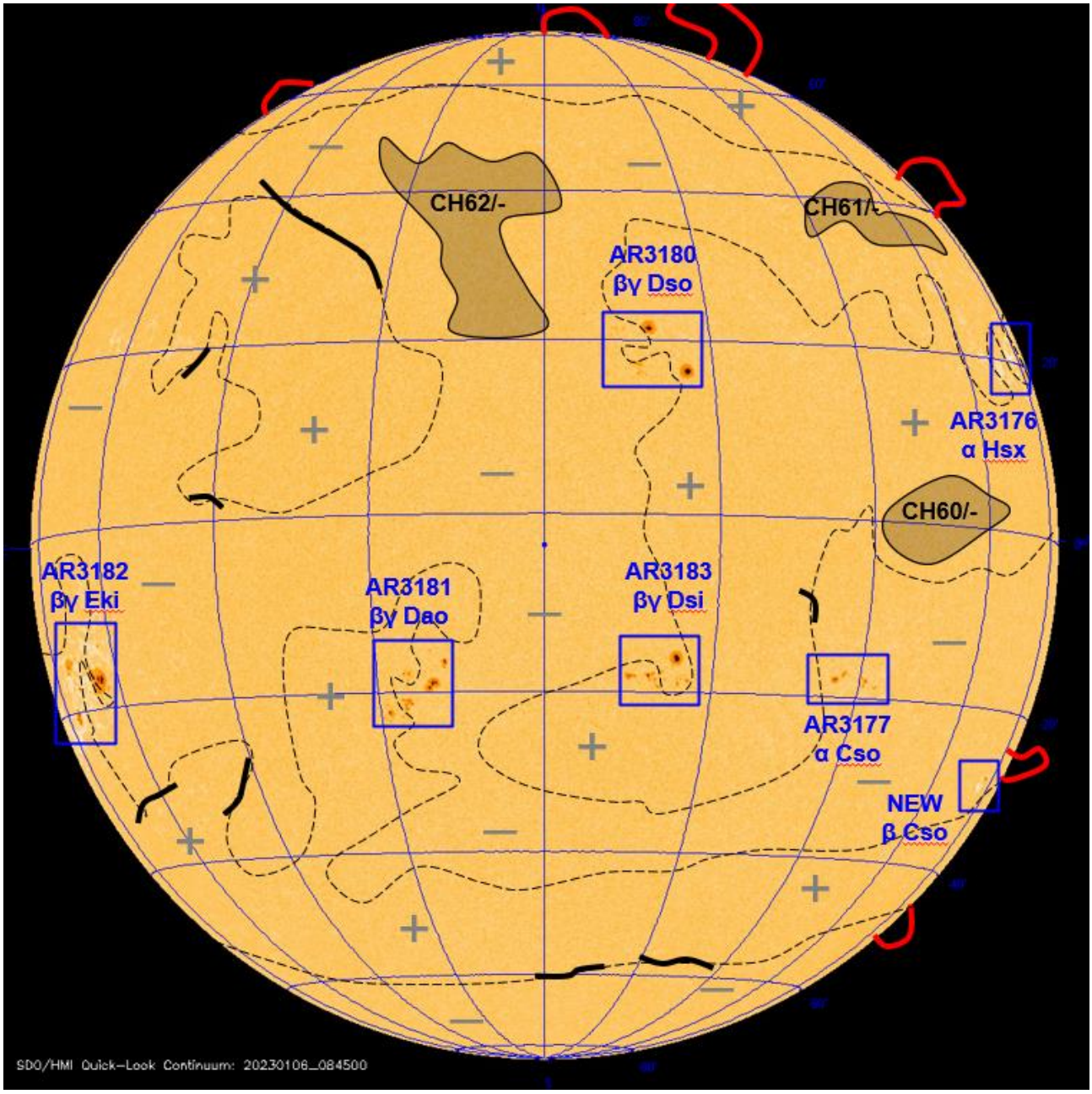
Figure 1. Solar Analysis Valid 06/0845 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A CME which left the Sun on 30 December impacted the Earth on 04 January, with the solar wind environment initially under the residual effects of this yesterday, but then late in the day a likely connection to a HSS appears to have occurred, either from CH60 or CH61. However, CH60 is no longer visible in SDO imagery and CH61 is now very faint. Therefore, the current HSS connection is expected to remain relatively weak, with speeds 450-500 km/s, and also brief.

A glancing CME impact is possible today (6th Jan) from a CME which left the Sun on 02 January, but this carries low confidence.
Geomagnetic activity is expected to be Quiet to Unsettled (Kp 2-3) today, with isolated Active (Kp 4) periods likely, and a slight chance of a G1/minor geomagnetic storm (Kp 5). From tomorrow (7th Jan) predominantly Quiet conditions are expected.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	20	5	1	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Nil - a slight chance of a CME which left the Sun on the 4th arriving at Earth today (6th) but this as low confidence.

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Radio Blackouts - X-Ray Flares:

There are six numbered sunspot regions on the visible disc, with one recently emerged and currently un-numbered sunspot region in the southwest quadrant. AR3182 remains the largest region on the disc and is currently classified as Eki/Beta-Gamma, although it's magnetic structure is complex and extends back around the southeast limb, therefore, the region is likely to become larger as it continues to rotate further away from the southeast. Potential for a delta spot to develop, which will continue to be monitored, as it rotates further onto the visible disc.

Both AR3176 and AR3177 on the western hemisphere remain uni-polar, with AR3177 showing some slight decay. AR3180 is stable and remains classified as a beta-gamma. AR3181, in the southeast, continues gradual increase in the trailing spots. AR3183 emerged quite rapidly in the southern hemisphere during the previous 24 hours, and is now classified as Dsi/Beta-Gamma.

AR3182 remains the most likely to produce further significant flares, and to a lesser extent AR3177 and AR3181, despite the simple classification of AR3177 which has a history of large C-class flares. Solar activity is likely to be Low to Moderate, with a chance of X-class flares. The probabilities of significant flares may increase further later in the period, as potentially new active regions could rotate onto the east limb.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	50	50	50	50
Very Active	R3 to R5 X Class	Yes	20	20	20	20

Figure 2: GOES-16 X-Ray flares – shows the X1.2 from AR3182.

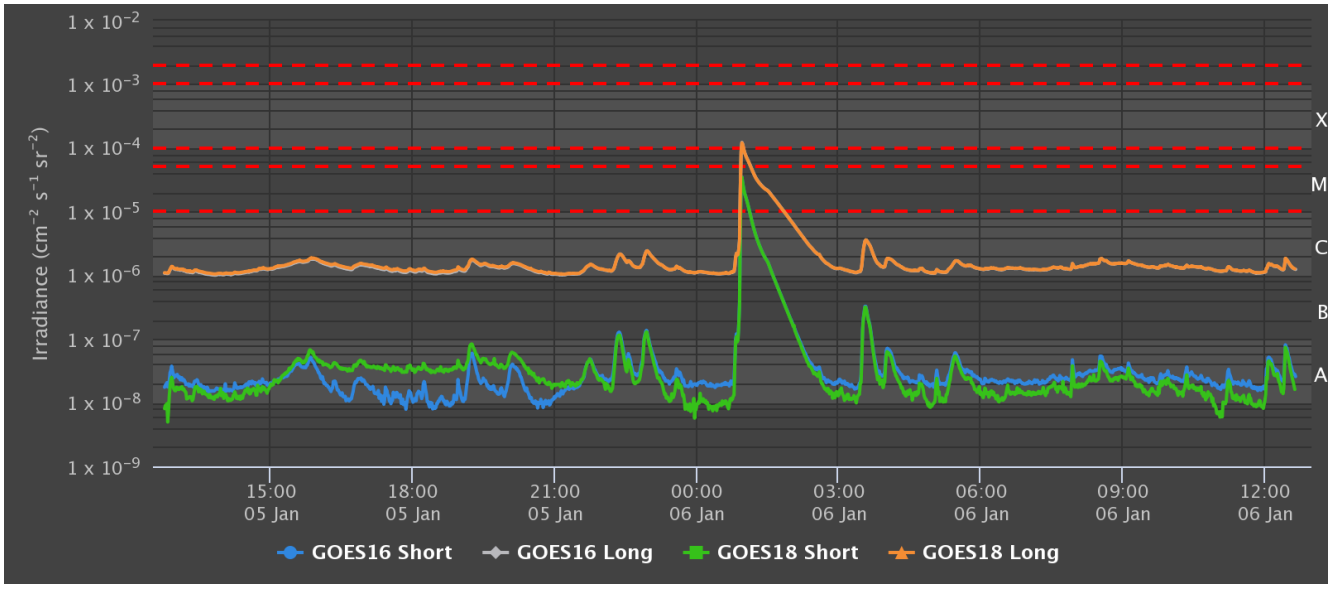

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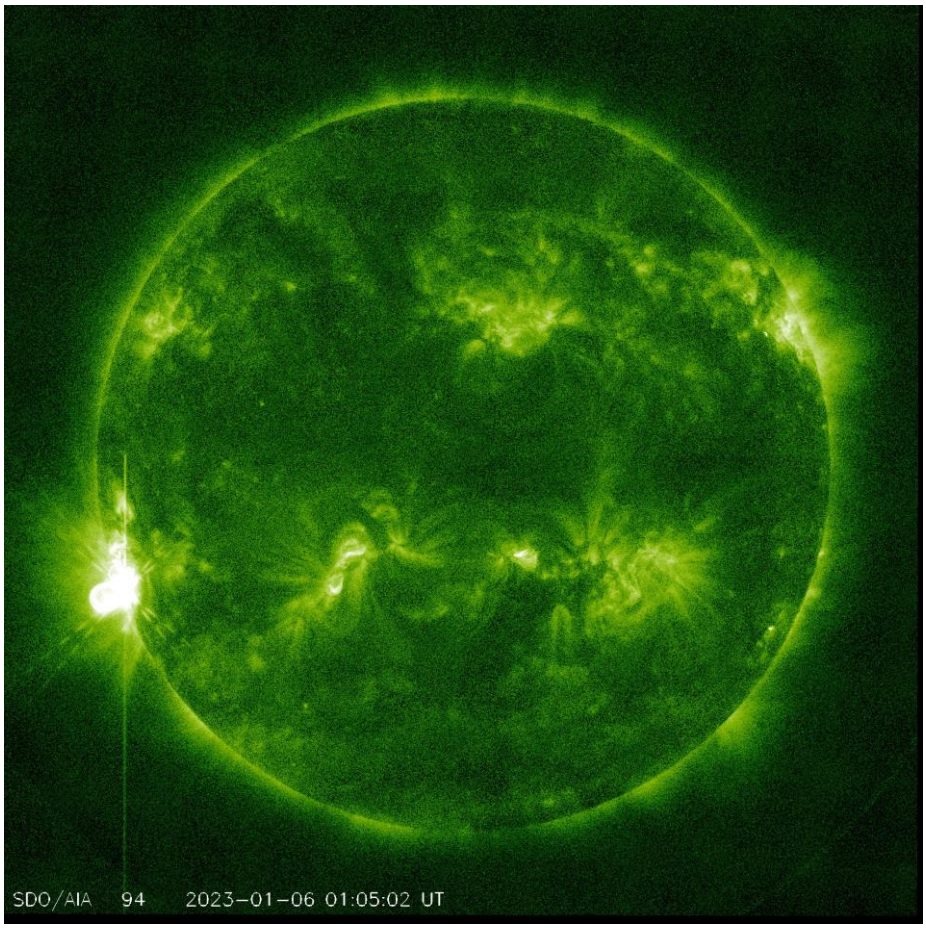
Figure 3: SDO/AIA 94 shows the X1.2 originating from AR3182 in the southeast quadrant.



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Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) measured by GOES-16 is at background levels. Any significant flares will bring a risk of proton flux rising at points during the period, with a slight chance of exceeding the S1/Minor Storm threshold. This risk increases slightly through the period, due mainly to the risk presented by AR3182 as it rotates further across the visible disc.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	10	20	20
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) has been at background to moderate levels. Despite the apparent connection to a high speed stream from either CH60 or CH61, as the connection is relatively weak so the high energy flux levels are expected to remain at background to moderate levels. The corresponding electron fluence values are forecast to remain below the Active (1e8 integrated pfu) levels, despite an increasing trend. The Met Office REFM model is therefore considered to be offering good guidance.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	10	20	30	40
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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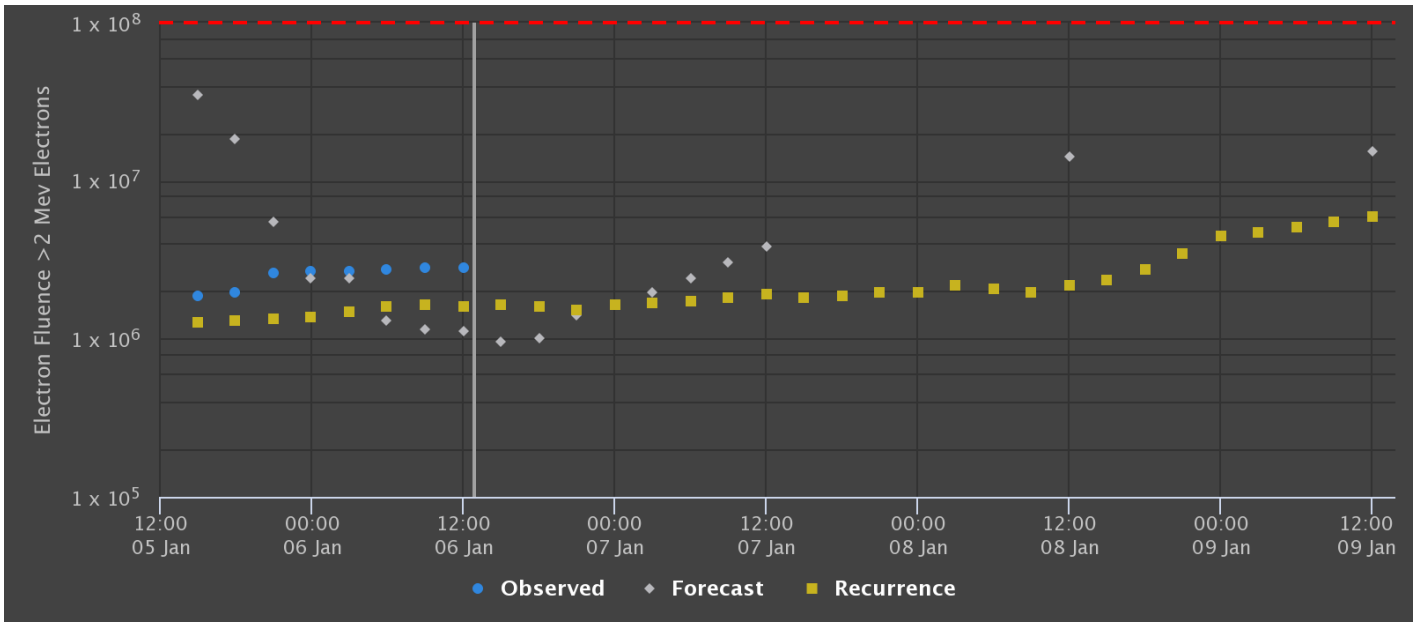
Figure 4: Met Office REFM model and observations.



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